AIR QUALITY MONITORING CONSIDERATIONS FOR THE EASTERN RIVERS AND MOUNTAINS NETWORK

Tonnie Maniero
NER Air Quality Ecological Effects Coordinator
May 2004

Introduction

As part of the National Park Service (NPS) Inventory and Monitoring (I&M) Program's Vital Signs scoping process, the Eastern Rivers and Mountains Network (ERMN) will evaluate the need for ambient air quality and air pollution effects monitoring in Network parks. This report contains background and summary air quality information to assist Network staff in that effort. On-site and nearby off-site ambient air quality data were used in conjunction with park-specific resource information to evaluate the following relative to the ERMN: 1) the need for additional ambient air quality monitoring at any Network park, i.e., wet deposition, dry deposition, visibility, and/or ozone monitoring, and 2) the need for air quality effects-related monitoring at any Network park. The results of this evaluation are discussed below.

The evaluation for ERMN parks relied on data collected through a number of Federal- and state-sponsored ambient air quality monitoring programs. Monitor locations, site numbers, and distances from ERMN parks are provided in Tables 1 and 2. Maps displaying monitor locations and graphics summarizing monitoring data are provided in a separate PowerPoint file as an addendum to this report.

The evaluation used products developed by the NPS Air Resources Division (ARD) specifically for the I&M Program. In 2004, the ARD finalized an Air Quality Inventory for I&M parks. The Air Quality Inventory consists of GIS-based maps and associated look-up tables that provide baseline values for a set of air quality parameters for all I&M parks. The values are based on averaged 1995 to 1999 data. Because ozone is a regional pollutant, in most cases the look-up table values are likely representative of ozone concentrations in a park. Greater variability, and uncertainty, may exist for deposition and visibility values, since those pollutants are more likely to be influenced by meteorological differences. Air Quality Inventory products are contained in the NPS Air Atlas (http://www2.nature.nps.gov/air/maps/airatlas/). NPS Air Atlas estimates for select air quality parameters for ERMN parks are provided in Appendix 1 of this report, and a description of those parameters is provided in Appendix 2.

In an ongoing project, ARD contracted with an ozone effects expert to assess the risk of ozone-induced foliar injury on sensitive vegetation in I&M parks. The risk assessments are based on NPS Air Atlas ozone values, the Palmer Z Drought Index and park vascular plant lists. The risk assessments will be finalized, distributed, and posted on the ARD website in summer 2004. In the meantime, draft risk assessments for the ERMN are attached as Appendix 3.

Wet Deposition

The National Atmospheric Deposition Program/National Trends Network (NADP/NTN) is a nationwide network of precipitation monitoring sites. The network is a cooperative effort between many different groups, including the U.S. Environmental Protection Agency (EPA), U.S. Geological Survey, U.S. Department of Agriculture, and private entities. The NPS is a major participant in NADP/NTN, and the ARD recommends that any new wet deposition site installed in a park meet NADP/NTN siting criteria and follow NADP/NTN monitoring protocols. There are currently more than 200 NADP/NTN sites spanning the continental U.S., Alaska, Puerto Rico, and the Virgin Islands (http://nadp.sws.uiuc.edu/).

The purpose of the NADP/NTN network is to collect data on the chemistry of precipitation in order to monitor geographical and temporal long-term trends. The precipitation at each station is collected weekly according to strict clean-handling procedures. It is then sent to the Central Analytical Laboratory in Illinois where it is analyzed for hydrogen (acidity as pH), sulfate (SO_4), nitrate (NO_3), ammonium (NH_4), chloride, and base cations (such as calcium, magnesium, potassium and sodium). NADP/NTN's excellent quality assurance programs ensure that the data remain accurate and precise.

The NADP/NTN has also expanded its sampling to include the Mercury Deposition Network (MDN), which currently has over 35 sites. The MDN was formed in 1995 to collect weekly samples of precipitation, which are analyzed for total mercury. The objective of the MDN is to monitor the amount of mercury in precipitation on a regional basis (http://nadp.sws.uiuc.edu/mdn/).

The Pennsylvania Department of Environmental Protection (DEP), under a cooperative agreement with Pennsylvania State University, has maintained the Pennsylvania Atmospheric Deposition Monitoring Network since 1981. The purpose of the DEP program is to determine how much atmospheric deposition is falling in precipitation in the state (http://www.dep.state.pa.us/dep/deputate/airwaste/aq/acidrain/acidrain.htm). The DEP supports nine wet atmospheric deposition and six wet mercury deposition monitoring sites. The Pennsylvania Atmospheric Deposition Monitoring Network monitors the same parameters, follows the same protocols and uses the same quality assurance programs as NADP/NTN and MDN. More than half of the Pennsylvania Atmospheric Deposition Monitoring Network sites are in the NADP/NTN, and all the Pennsylvania DEP mercury monitoring sites are in the MDN.

Deposition varies with the amount of annual on-site precipitation, and is useful because it gives an indication of the total annual pollutant loading at the site. Concentration is independent of precipitation amount, therefore, it provides a better indication of whether ambient pollutant levels are increasing or decreasing over the years. In general, annual average wet deposition and concentration of SO_4, NO_3, and NH_4 are higher in the eastern than in the western U.S. At many NADP/NTN sites across the U.S., concentration and deposition of SO_4 have declined in recent years as sulfur dioxide emissions have decreased.

Trends have been variable for NO_3 and NH_4, with concentration and deposition at various sites increasing, decreasing, or showing no overall change.

Trend analyses have not yet been performed for MDN sites due to the relatively short time that sites have been in operation. MDN site PA13 (Allegheny Portage Railroad National Historic Site (NHS)) has been operating since 1997, site PA37 (Holbrook) has been operating since 1999, and site PA72 (Milford) was installed in 2000. MDN deposition maps show that, similar to SO_4 and NO_3, wet mercury deposition is higher in the eastern U.S. than in the western U.S. Highest wet mercury deposition values are consistently monitored at sites in Florida and along the Gulf of Mexico.

Allegheny Portage Railroad NHS has Pennsylvania Atmospheric Deposition Monitoring Network atmospheric deposition and mercury deposition monitors on-site; the rest of the parks in the ERMN have either a Pennsylvania Atmospheric Deposition Monitoring Network or a NADP/NTN monitor within 60 km. The 2002 NADP/NTN and Pennsylvania Atmospheric Deposition Monitoring Network wet deposition values for the ERMN were similar, and were consistent with the 1995 through 1999 Network averages contained in the NPS Air Atlas. Sulfate, NO_3 and NH_4 wet deposition ranged from about 16 to 25 kilograms per hectare per year (kg/ha/yr), 14 to 19 kg/ha/yr, and 2.3 to 3.7 kg/ha/yr, respectively. Converted to sulfur (S) and nitrogen (N), the ranges for the NADP/NTN and Pennsylvania Atmospheric Deposition Monitoring Network values were 5.3 to 8.3 kg/ha/yr for wet S deposition, and 4.9 to 7.1 kg/ha/yr for wet N deposition. The Air Atlas wet deposition values for ERMN parks were 4.4 to 6.6 kg/ha/yr for S and 3.5 to 6.8 kg/ha/yr for N. The NADP/NTN and Pennsylvania Atmospheric Deposition Monitoring Network wet concentration values for SO_4, NO_3 and NH_4 ranged from about 1.4 to 2.2 milligrams per liter (mg/l), 1.1 to 1.6 mg/l, and 0.2 to 0.34 mg/l, respectively.

With the exception of Bluestone National Scenic River (NSR), Gauley River National Recreation Area (NRA) and New River Gorge National River (NR), the remaining ERMN parks have a MDN monitor within 60 km. 2002 Mercury wet deposition values ranged from 9.1 to 9.4 micrograms per square meter, while mercury wet concentration values ranged from 7.7 to 9.0 nanograms per liter.

Trend results for NADP/NTN and Pennsylvania Atmospheric Deposition Monitoring Network sites in and near ERMN parks are summarized below.

<u>Allegheny Portage Railroad NHS</u>
Allegheny Portage Railroad NHS has been a Pennsylvania Atmospheric Deposition Monitoring Network site (PA13) since 1997. Data showed an increase in wet SO_4, NO_3 and NH_4 concentration, but no apparent trend in wet SO_4, NO_3 or NH_4 deposition.

<u>State College</u>
An NADP/NTN site (PA15 (Penn State)) has been operating at State College since 1983. Data showed a decrease in wet concentration and deposition of SO_4 and NO_3, but no apparent trend in NH_4 concentration and deposition.

Holbrook

The Holbrook Pennsylvania Atmospheric Deposition Monitoring Network site (PA37) has been operating since 1999. Trend data are not yet available for the site.

Pine Grove Mills

The Pine Grove Mills, Pennsylvania, NADP/NTN site (PA42 (Leading Ridge)) has been operating since 1979. Data showed a decrease in wet SO_4 concentration and deposition, but no apparent trend in concentration and deposition of NO_3 or NH_4.

Milford

Milford, Pennsylvania has had a NADP/NTN site (PA72) since 1983. Data showed a decrease in wet SO_4 and NO_3 deposition and concentration, but no apparent trend in wet NH_4 concentration and deposition.

Eggleston

The NADP/NTN site has been operating in Eggleston, Virginia (VA13 (Horton Station)) since 1978. Trend data are only available since 1987. Data showed a decrease in wet SO_4 concentration and deposition, but no apparent trend in concentration and deposition of NO_3 or NH_4.

Babcock State Park

Babcock State Park, West Virginia, has had a NADP/NTN site ((WV04) since 1983. Data showed a decrease in wet SO_4 concentration and deposition, but no apparent trend in concentration and deposition of NO_3 or NH_4.

Cedar Creek State Park

There has been a NADP/NTN site at Cedar Creek State Park, West Virginia (WV05), since 1999. Trend data are not yet available for the site.

Dry Deposition

The Clean Air Status and Trends Network (CASTNet) is the nation's primary source for atmospheric data to estimate dry acidic deposition. Established in 1987, CASTNet now comprises over 70 monitoring stations across the U.S. The majority of the monitoring stations are operated by EPA; however, approximately 20 stations are operated by the NPS in cooperation with EPA (http://www.epa.gov/castnet/). Each CASTNet dry deposition station measures: weekly average atmospheric concentrations of SO_4, NO_3, NH_4, sulfur dioxide, and nitric acid; hourly concentrations of ambient ozone; and meteorological conditions required for calculating dry deposition rates. Dry deposition rates are calculated using atmospheric pollutant concentrations, meteorological data, and information on land use, vegetation, and surface conditions. CASTNet complements the database compiled by NADP/NTN; therefore, CASTNet sites are located at or near NADP/NTN sites. Dry deposition monitoring is more difficult, and more expensive, than wet deposition monitoring; consequently, there are fewer CASTNet than NADP/NTN sites nationwide. Due to the small number of CASTNet sites, it is not possible to develop dry deposition isopleth maps such as those produced by NADP/NTN. Because CASTNet uses different monitoring and reporting techniques than NADP/NTN, the dry deposition amounts are

reported as S and N, rather than SO_4, NO_3 and NH_4. In addition, because CASTNet calculates dry deposition based on estimated deposition velocities, there is greater uncertainty in the reported values.

None of the ERMN parks have a CASTNet monitor on-site, but all parks have a monitor within 80 km. Data summaries and trend analyses for CASTNet sites near ERMN parks are provided below. All trend analyses cover the timeframe of 1989 through 2001, except for the Claryville site, which began in 1994.

Washington Crossing

The Washington Crossing, New Jersey, CASTNet site (WSP144) data showed decreasing trends in both dry S deposition and dry N deposition. Total S deposition at Washington Crossing was composed of 47 percent dry deposition and 53 percent wet deposition, while total N deposition was 35 percent dry and 65 percent wet.

Claryville

Data from the Claryville, New York, CASTNet site (CAT175) showed no apparent trend in dry S deposition, but a decreasing trend in dry N deposition. Total S deposition at Claryville was composed of 37 percent dry deposition and 73 percent wet deposition, while total N deposition was 33 percent dry and 67 percent wet.

State College

The State College, Pennsylvania, CASTNet site (PSU106 (Pennsylvania State University)) data showed a decreasing trend in dry S deposition, but no apparent trend in dry N deposition. Total S deposition at State College was composed of 51 percent dry deposition and 49 percent wet deposition, while total N deposition was 31 percent dry and 69 percent wet.

Laurel Hill State Park

Laurel Hill State Park, Pennsylvania, CASTNet site (LRL117) data showed a decreasing trend in dry S deposition, but no apparent trend in dry N deposition. Total S deposition at the site was composed of 46 percent dry deposition and 54 percent wet deposition, while total N deposition was 24 percent dry and 76 percent wet.

Eggleston

Data from the Eggleston, Virginia, CASTNet site (VPI120 (Horton Station)) showed a decreasing trend in dry S deposition, but no apparent trend in dry N deposition. Total S deposition at the site was composed of 48 percent dry deposition and 52 percent wet deposition, while total N deposition was 48 percent dry and 52 percent wet.

Cedar Creek State Park

The Cedar Creek State Park, West Virginia, CASTNet site (CDR119) data indicated a decreasing trend in dry S deposition, but no apparent trend in dry N deposition. Total S deposition at Cedar Creek State Park was composed of 25 percent dry deposition and 75 percent wet deposition, while total N deposition was 20 percent dry and 80 percent wet.

Surface Water and Fish Tissue Chemistry

It is generally accepted that surface waters with a pH below 6.0 and an acid neutralizing capacity (ANC) below 100 microequivalents per liter (μeq/l) are sensitive to acidification from atmospheric deposition. The ERMN is in a part of the country that has been heavily impacted by past and current mining activities, and water quality data from many of the Network parks typify surface waters affected by acid mine drainage. In such areas, impacts from atmospheric deposition would likely be inconsequential compared to those from mining.

For this evaluation, the NPS Water Resources Division's (WRD) *Baseline Water Quality Data Inventory and Analysis* reports were reviewed for all of the ERMN parks. In addition, state agency and the NPS Research Permit and Reporting System websites were reviewed for reports of any additional, relevant surface water chemistry data. The websites were also reviewed for information pertaining to any chemical analyses conducted on aquatic biota collected in park lakes, rivers, and streams. The results of the review are summarized below.

Allegheny Portage Railroad NHS and Johnstown Flood National Memorial (NMem)

A review of the 1999 *Baseline Water Quality Data Inventory and Analysis* report for Allegheny Portage Railroad NHS and Johnstown Flood NMem indicated surface waters in the area have been affected by mining and oil and gas development. Some water quality samples collected at acid mine discharge points in the parks had pH values less than 4.0 and ANC values of 0 μeq/l. Samples collected at Blair Gap Run, Marshy Tributary, and South Fork Little Conemaugh River had average pH values of about 6.5. Some of the samples had ANC values below 100 μeq/l; however, it was not clear if those water bodies were affected by acid mine drainage. Pennsylvania has a general, statewide fish consumption advisory to limit ingestion of contaminants from untested fish. In addition, more stringent advisories are in effect for a number of lakes and rivers in the Ohio and Susquehanna River Basins. These advisories are primarily for mercury, but in some locations, polychlorinated biphenyls (PCBs) or chlordane are also of concern (http://sites.state.pa.us/PA_Exec/Fish_Boat/fishpub/summary/sumconsumption.pdf).

Bluestone National Scenic River (NSR)

The 1995 *Baseline Water Quality Data Inventory and Analysis* report for Bluestone NSR indicated area surface waters have been affected by residential development, farming and coal mining. Water quality samples were collected in the park on Bluestone River, Little Bluestone River and Mountain Creek from 1960 to 1995. The samples had an average pH of about 7.5 and average ANC values well above 100 μeq/l. Surface waters in Bluestone NSR do not seem to be sensitive to acidification from atmospheric deposition. It does not appear that West Virginia has issued a fish consumption advisory for Bluestone NSR (http://www.wv.gov/Offsite.aspx?u=http://www.dep.state.wv.us/).

Delaware Water Gap National Recreation Area (NRA) and Upper Delaware Scenic and Recreational River (S&RR)

The 1995 *Baseline Water Quality Data Inventory and Analysis* report for Delaware Water Gap NRA and Upper Delaware S&RR indicated the area has relatively good water

quality. Water samples were collected from the Delaware River, as well as from a number of creeks and brooks in the area. All in-park pH values averaged 6.5 to 7.5. Relatively few ANC values were included in the WRD report and most of those data were collected prior to 1975. Some of the reported ANC values were below 100 μeq/l, but given the chemical techniques available at the time, the data may not be accurate. Extensive water quality sampling continues in both parks under the auspices of the New Jersey and Pennsylvania Departments of Environmental Protection, the U.S. Geological Survey and the Delaware River Basin Commission. Data collected at Long Pine Pond, in Delaware Water Gap NRA, indicates the pond may be acidic, with reported pH values of 5.5 and ANC values of zero. It is not clear if this pond is affected by acid mine drainage or some other point source of pollution. Fish, freshwater eels and invertebrates have also been collected in the Delaware River for chemical analyses. Based on samples collected in the mid-1990s, the Delaware River Basin has fish consumption advisories for mercury and PCBs.

Fort Necessity National Battlefield (NB)

A review of the 1997 *Baseline Water Quality Data Inventory and Analysis* report for Fort Necessity NB indicated sufficient data do not exist to determine the sensitivity of park surface waters to acidification. The only reported data were collected from one spring in the park in 1977. That sample had a pH of 6.0 and an ANC value of 400 μeq/l. Fish consumption advisories are in effect for many lakes and streams in the Ohio River Basin for mercury, PCBs and/or chlordane.

Friendship Hill National Historic Site (NHS)

The 1998 *Baseline Water Quality Data Inventory and Analysis* report for Friendship Hill NHS indicated surface waters in the area are affected by oil and gas development and mining. Previous in-park sampling focused on an area of active mine drainage into Ice Pond Run. It doesn't appear synoptic surface water chemistry sampling has been conducted in the park. Therefore, it is not possible to determine the sensitivity of surface waters in the park to acidification from atmospheric deposition. Fish consumption advisories are in effect for many lakes and streams in the Ohio River Basin for mercury, PCBs and/or chlordane. There is an advisory for the Monongahela River in Point Marion for PCBs and chlordane.

Gauley River National Recreation Area (NRA)

A review of the 1995 *Baseline Water Quality Data Inventory and Analysis* report for Gauley River NRA showed the area has been impacted by development and mining. Limited, but recent, in-park data exist for Gauley River, Meadow River and Peters Creek. The data indicate Peters Creek and Meadow Creek are well-buffered. Water samples from Gauley River had pH values of 6.7 to 6.8 and average ANC values of about 70 μeq/l. Typically, one would expect much higher ANC values in water samples with pH values above 6.0. The reason for the discrepancy in these values is unknown. It does not appear that West Virginia has issued a fish consumption advisory for the Gauley River.

New River Gorge National River (NR)

The 1995 *Baseline Water Quality Data Inventory and Analysis* report for New River Gorge NR indicated surface waters in the area have been affected by mining. The report showed that while the New River and most creeks in the park are well-buffered, Mill Creek and Dowdy Creek had pH values of 7.0 but ANC values below 100 μeq/l. The reason for the discrepancy between pH and ANC values is unknown. It does not appear that West Virginia has issued a fish consumption advisory for New River Gorge NR.

Particulate Matter

Small or "fine" particles in the air, typically those less than 2.5 microns in diameter, $PM_{2.5}$, are a leading cause of human respiratory illness. Particles are present everywhere, but high concentrations and/or specific types have been found to present a serious danger to human health. Fine particles in the air are also the main contributor to human-caused visibility impairment. The particles not only decrease the distance one can see; they also reduce the colors and clarity of scenic vistas.

The current human-health based National Ambient Air Quality Standards (NAAQS) for particulate matter (set by the EPA) are for particles 10 microns or less in diameter (PM_{10}). Areas where air quality exceeds the NAAQS for PM_{10} are designated "nonattainment" for that pollutant. There are PM_{10} monitors within 35 km of Allegheny Portage Railroad NHS, Delaware Water Gap NRA, Fort Necessity NB, Friendship Hill NHS and Johnstown Flood NMem. No designated PM_{10} nonattainment areas are located near ERMN parks (http://www.epa.gov/air/data/index.html).

In 1997, EPA finalized new stricter NAAQS for particulate matter based on $PM_{2.5}$. Nationwide $PM_{2.5}$ monitoring was initiated in 1999; nonattainment areas will not be designated until December 2004. There are $PM_{2.5}$ monitors within 35 km of Bluestone NSR, Delaware Water Gap NRA, Fort Necessity NB, Friendship Hill NHS, Gauley River NRA, and New River Gorge NR. Preliminary monitoring data for 2000 through 2002 indicate there will be no designated $PM_{2.5}$ nonattainment areas near parks of the ERMN (http://www.epa.gov/ttn/naaqs/pm/pm25_tech_info.html).

Visibility

In 1985, in response to the mandates of the Clean Air Act, Federal and regional/state organizations established the Interagency Monitoring of Protected Visual Environments (IMPROVE) program to protect visibility in Class I air quality areas. Class I areas are national parks greater than 5,000 acres and wilderness areas greater than 6,000 acres, that were established prior to August 7, 1977. All other NPS areas are designated Class II. The objectives of the IMPROVE program are to: establish current visibility conditions in all Class I areas; identify pollutants (particles and gases) and emission sources responsible for existing man-made visibility impairment; and document long-term trends in visibility. The IMPROVE network is designed to assess regional visibility; standard operation does not identify individual sources that impair visibility at a monitoring site (http://vista.cira.colostate.edu/improve/).

In 1999, there were 30 official IMPROVE sites and 40 protocol sites. Because of recently enacted Regional Haze regulations that require improving visibility in Class I areas, the number of visibility monitors has increased. Protocol sites were upgraded to full IMPROVE sites and 80 new sites were added to the IMPROVE network. While the IMPROVE program has focused on Class I air quality areas, a great deal of visibility monitoring has been conducted in Class II areas. Installation and annual operating costs for a full IMPROVE site are expensive. The ARD is currently developing a monitoring protocol for less-expensive view monitoring using a digital camera. While this type of monitoring would not be adequate for regulatory purposes, it is useful for documenting visibility conditions and trends and provides an excellent means of sharing that information with the public.

All ERMN parks have an IMPROVE monitor within 120 km. The sites are as follows: Edwin B. Forsythe National Wildlife Refuge (NWR), New Jersey (Brigantine, BRIG1), operating since 1991; Connecticut Hill, New York (COHI1), operating since 2001; Addison Pinnacle, New York (ADPI1), operating since 2001; Quaker City, Ohio (QUCI1), operating since 2001; Arendtsville, Pennsylvania (AREN1), operating since 2001; Natural Bridge, Virginia (James River Face WA, JARI1), operating since 2000; Shenandoah National Park (NP), Virginia (SHEN1), operating since 1988; and Davis, West Virginia (Dolly Sods Wilderness Area (WA), DOSO1), operating since 1991.

IMPROVE provides maps of visibility conditions at all monitoring sites, pie charts of the pollutants that contribute to visibility impairment at each site, and trend data for sites that have been operating 10 years or longer (http://vista.cira.colostate.edu/views/Default.htm). One measurement used to report visibility is light extinction, or b_{ext}, reported in inverse megameters (Mm^{-1}). Light extinction occurs when particles in the air scatter or absorb light; extinction generally increases as particle concentrations in the air increase. Therefore, the higher the b_{ext}, the worse the visibility. The Regional Haze regulations require improvements in visibility on both the best (clearest), and the worst (haziest), days. In general, visibility is much better in the western, than in the eastern, U.S.

2002 IMPROVE data indicated b_{ext} at ERMN parks on the best visibility days ranged from 21 to 35 Mm^{-1}. On the worst visibility days, b_{ext} at Network parks ranged from 139 to 173 Mm^{-1}. These values are consistent with the 1995 to 1999 values provided in the NPS Air Atlas, i.e., 30 to 35 Mm^{-1} on the best visibility days and 168 to 191 Mm^{-1} on the worst visibility days. IMPROVE data showed that at all eight sites near ERMN parks, on an annual basis, impairment in 2002 was due primarily to ammonium sulfate (sources include coal combustion and oil refineries). The remainder was due to ammonium nitrate (sources include coal and natural gas combustion and automobiles), organics (sources include automobiles), elemental carbon (sources include wood burning) and coarse mass (larger than $PM_{2.5}$; sources unknown).

Trend data are available for Edwin B. Forsythe NWR, Shenandoah NP, and Davis. The data indicate an improvement in visibility at both Edwin B. Forsythe NWR and Shenandoah NP on the best and worst visibility days. While the Davis data show an

improvement on days with worst visibility, there is no overall trend on days with best visibility.

Ozone

Ozone is created by a chemical reaction between oxides of nitrogen and volatile organic compounds in the presence of heat and sunlight. Some major sources of ozone-forming chemicals are motor vehicle exhaust and industrial emissions, gasoline vapors, and chemical solvents. High ozone concentrations cause respiratory problems in humans, and are a particular concern for those who are engaging in strenuous aerobic activity, such as hiking. Ozone also damages sensitive plant species. It injures plant leaves by causing a visible spotting or "stipple" on the upper surface of the leaves. Ozone can affect plant physiology by reducing growth, increasing susceptibility to disease, and increasing senescence.

None of the ERMN parks have continuous ozone monitors on-site, but passive ozone monitoring has been conducted during the summers of 1995 through 2003 at New River Gorge NR. All of the parks except Upper Delaware S&RR have continuous ozone monitors within 35 km. The Pennsylvania counties that contain Allegheny Portage Railroad NHS, Delaware Water Gap NRA, Friendship Hill NHS, Johnstown Flood NMem, and Upper Delaware S&RR are designated nonattainment for the existing 1-hour ozone NAAQS. There are no 1-hour ozone nonattainment areas in West Virginia. EPA established a new NAAQS for ozone, which is based on an 8-hour ozone concentration, and they recently published their proposed list of nonattainment areas for the 8-hour standard (http://www.epa.gov/ttn/naaqs/ozone/index.html). While West Virginia has some proposed 8-hour ozone nonattainment areas, none are near ERMN parks. With the exception of Upper Delaware S&RR, all ERMN parks in Pennsylvania are in proposed 8-hour ozone nonattainment areas. Based on the 1995 to 1999 ozone values contained in the Air Atlas, all ERMN parks could be nonattainment for the 8-hour ozone NAAQS.

The NPS focuses on plant sensitivity to ozone for a couple of reasons. First, ozone is a regional pollutant and is, therefore, more likely to affect park resources than other gaseous pollutants such as sulfur dioxide and nitrogen oxide which quickly convert to other compounds. Second, the literature on ozone sensitivity is more recent and more reliable than that for other pollutants. The ARD contracted with an ozone effects expert from Cornell University to perform ozone injury risk assessments for all parks in the NPS I&M program. The risk assessments relied on the ozone concentration data provided in Air Atlas, vascular plant lists contained in NPSpecies, a list of ozone-sensitive vascular plant species developed at a 2003 expert workshop convened by the ARD (http://www2.nature.nps.gov/air/Pubs/index.htm), and the Palmer Z Index, which is used to indicate soil moisture status. Note that the ARD workshop report provides a general guide to ozone sensitivity. Differences in plant genetics, weather conditions, soil water availability, and ozone concentrations will affect whether or not a species exhibits injury in a park. In particular, studies have shown that plants will not take up ozone unless there is sufficient soil moisture. The risk assessments for the ERMN parks (Appendix 3) indicate the risk of ozone-induced foliar injury of sensitive vegetation is moderate at Allegheny Portage Railroad NHS, Bluestone NSR, Gauley River NRA, Johnstown Flood

NMem, and New River Gorge NR, while the risk is high at Delaware Water Gap NRA, Fort Necessity NB, Friendship Hill NHS and Upper Delaware S&RR.

The U.S.D.A. Forest Service Forest Health Monitoring (FHM) program administers a nationwide biomonitoring program in partnership with the EPA and states. Ozone injury surveys are one component of the FHM program. According to a recent publication, FHM surveys in 2000 detected ozone injury on plots in the vicinity of all Pennsylvania parks in the ERMN; no injury was observed on plots located near West Virginia parks in the ERMN (Smith et al. 2003. *Environmental Monitoring and Assessment* 87:271-291). Because FHM does not provide plot location information, it is not known how close the plots are to NPS lands. A review of the NPS Research Permit and Reporting System shows that 16 FHM plots were established in and near Delaware Water Gap NRA in 2002. It is not known if ozone injury surveys were conducted on those plots.

Conclusions

All ERMN parks have both wet and dry deposition monitors within 80 km. Most likely, this coverage is adequate for Network parks. The ERMN parks in Pennsylvania all have MDN monitors within 60 km; none of the West Virginia parks have representative wet mercury deposition monitoring.

Assessing the sensitivity of ERMN park surface waters to atmospheric deposition is confounded by impacts from acid mine drainage in many of the parks and a shortage of recent data. Given the fish consumption advisories for mercury, PCBs and chlordane in Pennsylvania and West Virginia, the ERMN may want to consider long-term monitoring of contaminant levels in fish or other biota.

With the exception of Upper Delaware S&RR, particulate matter is monitored within 35 km of all ERMN parks. IMPROVE sites are located within 120 km of all Network parks. This coverage is likely adequate for assessing trends in regional visibility. If visibility impairment is a particular concern for any Network park, the ERMN may want to consider installing a digital camera to record and interpret visibility conditions.

With the exception of Upper Delaware S&RR, all ERMN parks have an ozone monitor within 35 km. The ERMN may want to consider installing a portable ozone monitor (Appendix 4) in parks where nearby monitors or the interpolated Air Atlas ozone estimates may not be representative of park conditions. It would be useful to document ozone concentrations at Upper Delaware S&RR, since the area is designated nonattainment for the 1-hour NAAQS but EPA is proposing to designate the area attainment for the 8-hour NAAQS.

The ozone injury risk assessments funded by the NPS ARD indicate a moderate to high risk of ozone injury of sensitive vegetation in all ERMN parks. The Network may want to consider conducting foliar injury surveys in ERMN parks.